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Publication number:

0 644 417 A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: **94114358.8**

(51) Int. Cl.⁶: **G01N 21/90**

(22) Date of filing: **13.09.94**

(30) Priority: **16.09.93 US 122843**

(43) Date of publication of application:
22.03.95 Bulletin 95/12

(84) Designated Contracting States:
**AT BE CH DE DK ES FR GB GR IE IT LI MC NL
PT SE**

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(54) **Inspection of translucent containers.**

(57) Apparatus for detecting checks in the sidewall of a translucent container (22) that includes a light source (24) for illuminating an elongated strip of the container sidewall parallel to the central axis of the container in such a way that illumination rays are incident at any point of the strip from multiple differing angles. A camera (50) is positioned externally of the container for receiving light reflected by checks in the illuminated strip, and electronic circuitry (52) is coupled to the camera for detecting checks in the container as a function of such reflected light. Since the light rays at any point in the elongated illuminated strip on the container sidewall are incident from multiple differing angles, planar checks and split seams in the container sidewall that are not precisely vertical in orientation will have a greater chance of reflecting light energy from the source onto the camera.

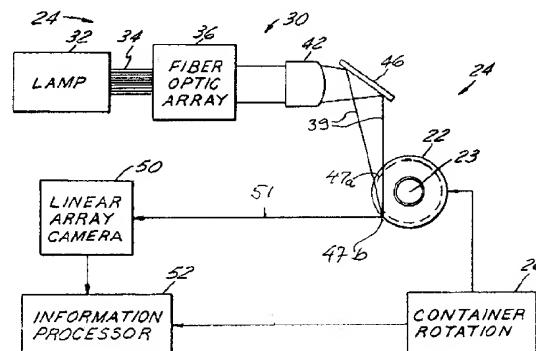


FIG. 1

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The present invention is directed to optical inspection of translucent containers, and more specifically to an apparatus and method for detecting so-called vertical checks and split seams in the sidewalls of translucent containers.

Background and Objects of the Invention

In the manufacture of translucent containers such as clear or colored glass bottles, various types of checks or other commercial variations can occur in the sidewalls of the containers. For example, variations known as split seams and vertical checks may be present in the sidewall of a container. These split seams and vertical checks are mirror-like reflective cracks that lie in a plane and extend generally radially from the longitudinal axis of the container. Many devices have been proposed for detecting such variations.

U. S. Patent No. 4,584,469 discloses a device for detecting split seams and vertical checks in the sidewall of a glass container. A light source is positioned to one side of the container to direct light energy onto the container wall from a direction perpendicular and lateral to the container axis. The light source comprises an incandescent bulb and a cylindrical lens for projecting an image of the bulb filament onto the container sidewall in an elongated narrow tightly focused strip parallel to the container axis. A linear array camera is positioned to receive an image of the illuminated portion of the container from a direction perpendicular to the illumination and container axes. As the container is held in position and rotated about its axis, a radial planar check will eventually be rotated into a position to reflect light from the source to the detector. Thus, the vertical check or split seam is detected as a bright spot on what is otherwise a normally gray or dark background viewed by the detector. (Directional terms such as "vertical" assume vertical orientation of the container axis with the mouth opening upwardly, as is typical in the container inspection art.)

Although the device disclosed in the noted patent has enjoyed substantial commercial success, further improvements remain desirable. In particular, the device disclosed in the noted patent is limited in its ability to detect checks that are not precisely vertical and parallel to the container axis. That is, if a check is non-vertical, light incident on the check will be reflected by the check but not necessarily incident on the camera. It is therefore a general object of the present invention to provide an apparatus and method of the general character or type disclosed in the above-noted patent having enhanced ability to detect and inspect non-vertical radial checks and split seams in the container sidewall.

Summary of the Invention

Apparatus for detecting checks in the sidewall of a translucent container in accordance with a presently preferred embodiment of the invention includes a light source for illuminating an elongated strip of the container sidewall parallel to the central axis of the container in such a way that illumination rays are incident at any point of the strip from multiple differing angles. A camera is positioned externally of the container for receiving light reflected by checks in the illuminated strip, and electronic circuitry is coupled to the camera for detecting checks in the container as a function of such reflected light. Since the light rays at any point in the elongated illuminated strip on the container sidewall are incident from multiple differing angles, as distinguished from substantially unidirectional illumination in the above-noted patent, planar checks in the container sidewall that are not precisely vertical in orientation will have a greater chance of reflecting light energy from the source onto the camera.

In the preferred embodiment of the invention herein disclosed, the light source comprises a fiber-optic ribbon having ends disposed in an essentially linear array optically parallel to the container axis, and a cylindrical lens disposed between the fiber-optic ribbon array and the container for focusing light from the array in a direction perpendicular to the container axis to form the narrow elongated illumination strip. In this way, the light rays incident on the container sidewall are oriented at multiple angles essentially in a plane parallel to the container axis. The fiber-optic ribbon has a dimension parallel to the central axis of the container at least as great as the longitudinal dimension of the illuminated strip. The camera preferably comprises a linear array of light sensitive elements optically parallel to the container axis and the illuminated strip, with the camera array being scanned by detection electronics at increments of container rotation.

Brief Description of the Drawings

The invention, together with additional objects, features and advantages thereof, will be best understood from the following description, the appended claims and the accompanying drawings in which:

FIG. 1 is a functional block diagram of apparatus for inspecting translucent containers in accordance with the present invention;

FIG. 2 is a schematic diagram of a portion of the container and a portion of the light source in the apparatus of FIG. 1;

FIG. 3 is an end elevational view of a portion of the light source taken substantially along the line 3-3 in FIG. 2;

FIG. 4 is a top plan view of a portion of the light source illustrated in FIGS. 1-3; and

FIG. 5 is a fragmentary sectional view taken substantially along the line 5-5 in FIG. 4.

Detailed Description of Preferred Embodiment

Referring to the drawings, a conveyor 20, typically including a starwheel (not shown) and a slide plate 21, is so disposed and connected to a source of molded containers as to bring successive containers 22 into position at an inspection station 24. Conveyor 20 may be of any suitable type, such as those shown in U.S. Patent Nos. 4,230,219 and 4,378,493 as well as above-noted U.S. Patent No. 4,584,469, and would typically include a rotatable starwheel for bringing successive containers into position and holding the containers in fixed position during the scanning operation. A container rotating device 26, such as a drive roller, is positioned to engage container 22 at station 24 and to rotate the container about its central axis 23. An encoder or the like is coupled the container rotation mechanism to provide signals indicative of increments of container rotation. Alternatively, with the container rotating at constant speed, increments of container rotation may be inferred by increments of time.

A light source 30 is positioned to one side of container 22 at station 24 for directing light energy on the container at the station. Light source 30 comprises a lamp 32 with power supply and is connected by a fiber-optic bundle 34 to a fiber-optic array 36. As shown in FIG. 3, fiber-optic array 36 comprises a linear essentially one-dimensional array of individual fiber-optic elements 38. Preferably, fiber-optic cable 34 feeds into a housing 40 in which the bundle 34 is essentially fanned into a plane that is essentially one fiber-optic element thick, with the end faces of the fiber-optic elements 38 thereby terminating in the linear array illustrated in FIG. 3. Fiber-optic array 36 preferably comprises several hundred individual fiber-optic elements 38 fanned into the planar array forming a ribbon (FIG. 3). A cylindrical lens 42 is mounted by suitable bracketry 44 (FIGS. 4 and 5) at a position spaced from the fiber-optic array 36. A mirror 46 is fastened to light source bracketry 44 at an angle to lens 42 for reflecting light energy from array 36 and lens 42 through the sidewall of container 22, at which the light is focused to a narrow vertical strip 47 (actually two strips 47a, 47b at the front and rear sides, respectively, of the container 22, seen from the mirror 46, are illuminated). A clamp 48 is fastened to light source bracketry 44 for vertically and angularly adjusting orientation of the assembly

relative to the container at inspection station 24.

A linear array camera 50 (FIG. 1) is positioned relative to container 22 at station 24 for receiving light energy from light source 30 reflected by checks in the container sidewall. Preferably, an axis 51 of the camera 50 for viewing to the illuminated strip 47 is chosen which is perpendicular to the plane of illumination by the light source 30, some deviation from that plane being possible. Camera 50 includes a linear array of photosensitive elements, the light receiving surfaces thereof being oriented optically parallel to axis 23 of container 22 at inspection station 24. An information processor 52 is coupled to linear array camera 50 and container rotation mechanism 26 for scanning the elements of camera 50 at increments of container rotation, and thereby receiving from the camera image data indicative of any checks in the sidewall of container 22 that reflect light from source 30 onto the camera. Linear array camera 50, information processor 52 and container rotation mechanism 26 may be of the type disclosed in above-noted U.S. Patent No. 4,584,469, the disclosure of which is incorporated herein by reference for purposes of background. Alternatively, camera 50 may be an area array camera of the type disclosed in copending U.S. Patent No. 5,200,801 assigned to the assignee thereof.

The ends of the individual fiber-optic elements 38 function in effect as individual light sources from which light rays emerge and diverge toward cylindrical lens 42. Lens 42 functions to focus the light rays 39 in the plane of FIG. 1, which is perpendicular to the container axis 23 but does not substantially affect or bend the path of travel of such individual light rays which are parallel to the container axis 23 or, in effect, take an acute angle thereto, as shown in FIG. 2 by the light rays 62. Thus, the light rays from the individual fiber-optic element ends diverge and intersect each other so that, when incident on the container sidewall, they travel essentially in a tightly focused plane which is parallel to the container axis, but intersect and illuminate the container sidewall from multiple differing angles within that plane. The overall vertical dimension of the illumination beam may be limited as illustrated by the solid lines 60 in FIG. 2, while the light rays 62 illustrate the angles of illumination of a check or split seam 64 in the sidewall of container 22. Because of the multiple differing angles at which the light is incident on split seam 64, the likelihood of detecting the split seam 64 at camera 50 is greatly enhanced even if the split seam is not oriented exactly or substantially parallel to the container axis 23.

Claims

1. Apparatus for detecting checks and/or split seams (64) in a translucent container (22) having a sidewall and a central axis comprising:
 - a source (30) of light for illuminating an elongated narrow strip (47) of the container sidewall parallel to the container axis (23),
 - a camera (50) positioned externally of the container (22) for receiving light reflected by checks (64) in the illuminated strip (47) of the container (22) along a reflection axis (51) preferably perpendicular to the axis of illumination from said light source, and
 - means (52) responsive to said camera for detecting checks in the container as a function of such reflected light,
 - characterized in that said light source (30) illuminates said strip (47) in such a way that illumination rays (60, 62) are incident at any point of said strip from multiple angles essentially coplanar with each other and with the strip, such that detection of non-vertical radiant checks and split seams (64) in the container sidewall is improved.
2. The apparatus set forth in claim 1 wherein said camera (50) comprises a linear array of light sensitive elements optically parallel to the container axis.
3. The apparatus set forth in claim 2 further comprising:
 - means (26) for rotating the container (22) about its central axis (23), and means (52) for scanning said linear array of light sensitive elements at increments of container rotation.
4. The apparatus set forth in any preceding claim wherein said light source (30) comprises a fiber-optic ribbon (36) coupled at one end to a source of illumination (32) and disposed at a second end to project said illumination onto said elongated strip (47) of the container sidewall.
5. The apparatus set forth in claim 4 wherein said fiber-optic ribbon (36) at said second end forms essentially a linear array of individual fiber-optics (38).
6. The apparatus set forth in claim 5 wherein said light source (30) further comprises a cylindrical lens (42) for focusing light from said fiber-optic ribbon (36) in said narrow strip (47).
7. The apparatus set forth in claim 5 wherein said fiber-optic ribbon (36) has a dimension parallel to the central axis (23) of the container (22) at least as great as the dimension of the illuminated strip (47) of the container (22) parallel to such axis (23).
8. The apparatus set forth in claim 7 wherein said light source (30) further comprises means (48) for adjustably positioning said light source with respect to the container (22) and camera (50).
9. A method of inspecting translucent containers (22) comprising the steps of:
 - (a) illuminating an elongated strip (47) of the sidewall of the container in such a way that illumination rays are incident at any point within the strip at multiple angles (62),
 - (b) directing light energy reflected by checks (64) in the illuminated strip (47) onto a photosensitive means (50), and
 - (c) detecting checks in the container sidewall as a function of such reflected energy.
10. The method set forth in claim 9 wherein said step (a) is carried out by directing light energy onto said illuminated strip (47) through a fiber-optic bundle (34) in which the individual optical fibers (38) are disposed in a linear array (36), the end faces thereof being optically parallel to the illuminated strip (47).
11. The method set forth in claim 10 comprising the additional step of:
 - (d) rotating the container (22) about its central axis (23) at an orientation in which such axis is parallel to the illuminated strip (47) on the container sidewall.

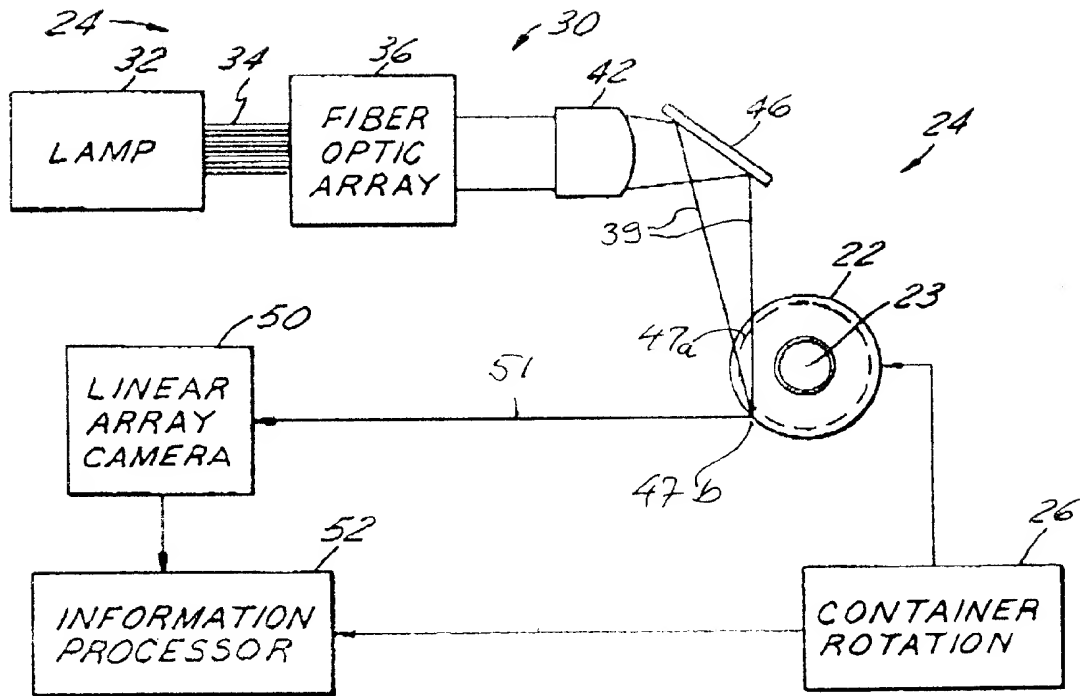


FIG. 1

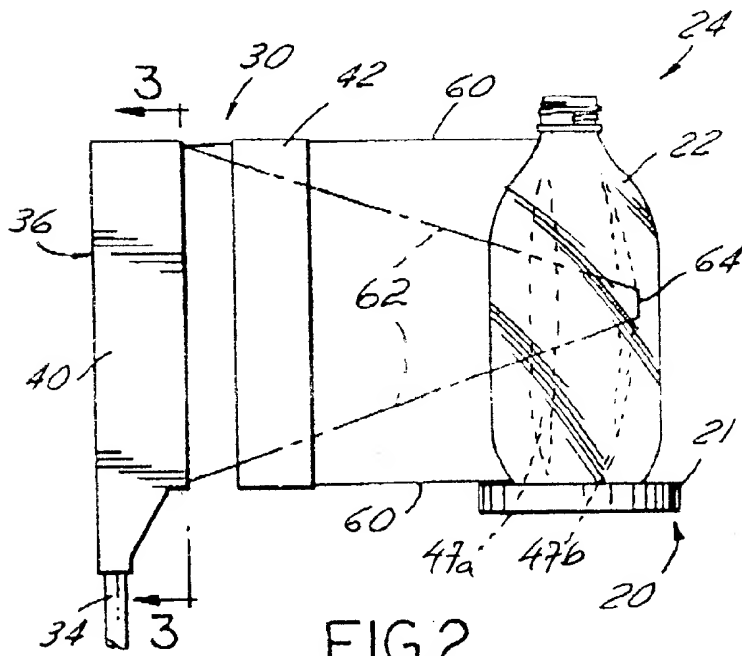


FIG. 2

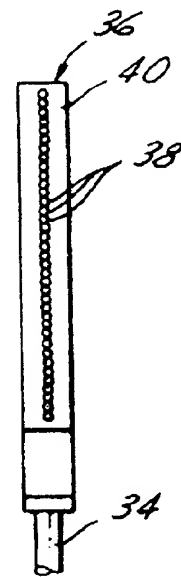


FIG. 3

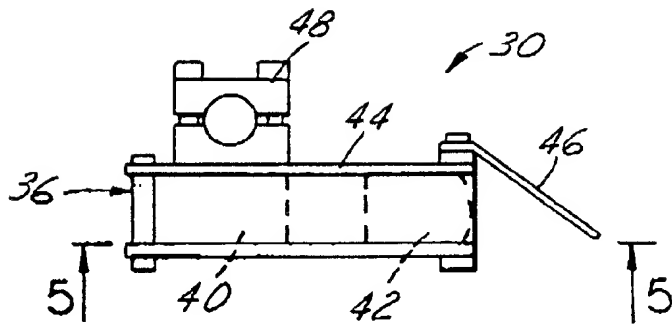


FIG. 4

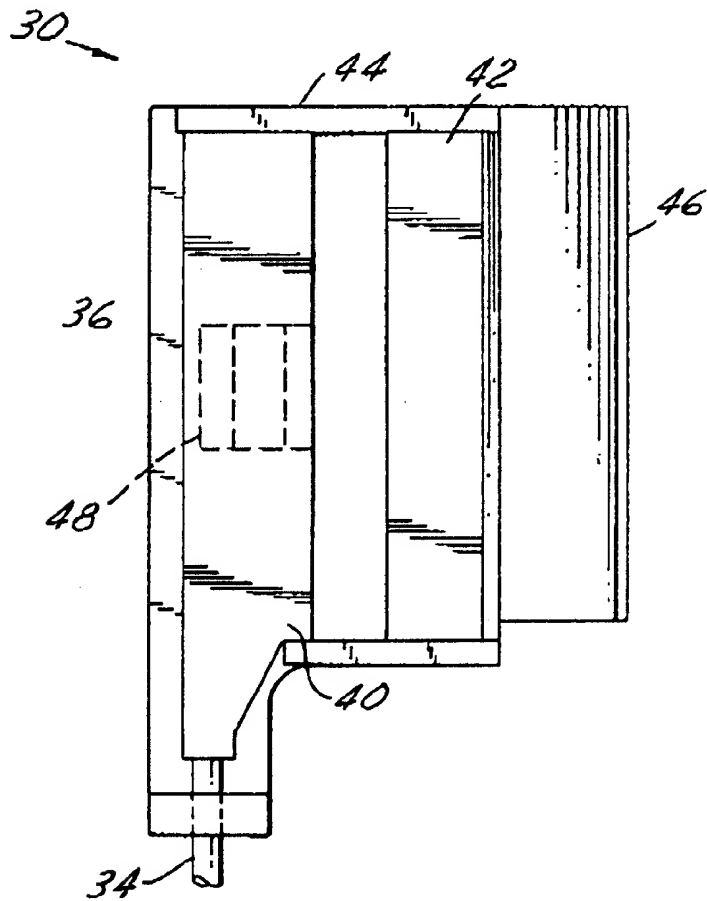


FIG. 5



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EUROPEAN SEARCH REPORT

Application Number
EP 94 11 4358

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	GB-A-2 133 538 (OWENS-ILLINOIS) * abstract * * page 1, line 121 - page 2, line 9 * * page 2, line 40 - line 49 * * page 3, line 34 - line 37 * * page 3, line 52 - line 130 *	1-3	G01N21/90
Y	* figures 1-3 *	4-6,9-11	
D	& US-A-4 584 469 (LOVALENTI) ---		
Y	US-A-3 588 258 (SENDT) * abstract * * column 2, paragraph 4 -paragraph 6 * * column 2, paragraph 9 -paragraph 11 * * figure 3 *	4-6,9-11	
A	GB-A-1 115 542 (STEINKOHLBERGWERKE STINNES) * page 2, line 44 - line 56; figures 1,2 *	1,9	
A	PATENT ABSTRACTS OF JAPAN vol. 4, no. 156 (P-34) (638) 31 October 1980 & JP-A-55 104 744 (SHIMAZU SEISAKUSHO) 6 February 1979 * abstract *	1,9	TECHNICAL FIELDS SEARCHED (Int.Cl.6) G01N
A	US-A-3 639 067 (STEPHENS) * abstract * * column 3, line 4 - line 10 * * column 3, line 34 - line 35 * * column 4, line 40 - line 54 * * figures 4,5,8 *	1,6,8-11	
A	FR-A-1 369 597 (FOSTER) * page 3, right column, line 35 - line 44; figure 2 * -----	1,4,5,9,10	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 14 December 1994	Examiner Thomas, R.M.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			